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Evaluation of Best Management Practices for Stream Retoration Projects

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EVALUATION OF BEST MANAGEMENT PRACTICES FOR STREAM RESTORATION PROJECTS

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Introduction:

The Freshwater Research Institute (FRI) at Susquehanna University has partnered with the Chesapeake Conservancy on a multi-year project to restore local rivers and streams through precision conservation techniques. This project focuses on macroinvertebrate and fish species and population as well as sediment characteristics over time at forested sites, impaired agricultural sites with no restoration, and those impaired agricultural sites with various implemented BMPs. Some implemented BMPs include mudsills, riparian buffers, and fencing to restrict livestock. The implemented techniques are based off of Dave Rosgen's Natural Channel Design (NCD) for stream and river restoration. Although this is the most widely used method for classifying streams and rivers, it has many scientific critiques due its oversimplified approach. For this reason, the type of restoration techniques implemented in a stream restoration project are not always the most effective for the particular location, and in fact, some projects can even prove to be more disruptive to the aquatic ecosystems in the long run. That said, there is minimal research on what actually are the most effective BMPs, particularly for smaller scale stream restoration projects. It is the goal of this project to analyze the "As Built" site plans for each site with implemented BMPs and conduct statistical analyses between the overall health of the stream site (determined by fish population data) with the implemented BMPs. This will allow for the creation of a ranking of BMPs or BMP categories in order to guide restoration managers toward the most effective technique for the site-specific conditions. It is expected that streams with a greater quantity of BMPs installed would result in healthier, more abundant fish populations.

Figure 1: Electroshocking for fish populations at a site with mudsills as the implemented BMP

Figure 2: Cross Vanes as an implemented BMP

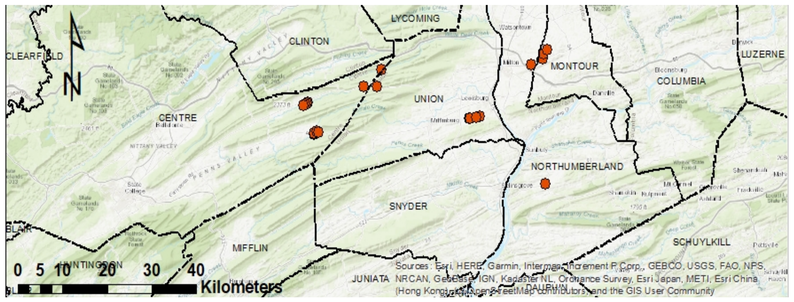

Figure 3: Sample site locations; 19 restored sites and 4 forest reference sites

Methods:

Twenty-four sites were examined using Pennsylvania Fish and Boat Commission one-pass electrofishing standard procedures. Fish population density was calculated by factoring average stream width for each 100-meter stream reach. Forest reference streams (4) were surveyed with attention to certain qualities that could be related to restoration techniques (as outlined in Figure 6). The restoration site plans were categorized beginning with all techniques used and listed on the site plan and narrowing it down into the following three categories: instream, riparian, and agricultural. The four narrowing steps are shown in Figure 6. There were substantial differences in many site plans (as shown in the contrast between Figures 4 and 5), so some terminology was standardized. R-Studio was used to conduct a Redundancy Analysis (RDA) to help identify some BMPs that were stronger indicators of the differences in fish populations between sites. Linear Regression models were used to further identify connections between fish populations and BMPs.

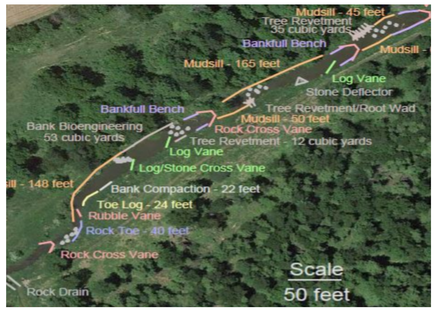

Figure 4: "As Built" site plan at Elk Creek, Pointer Haven location indicating primarily in-stream BMPs

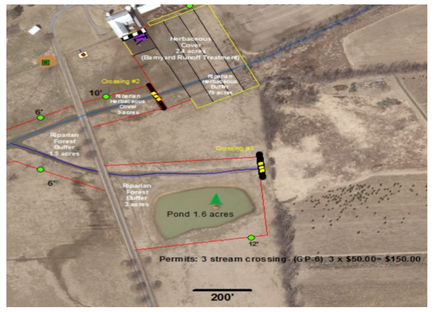

Figure 5: "As Built" site plan at Spring Creek, Dreiblebis location indicating primarily agricultural BMPs

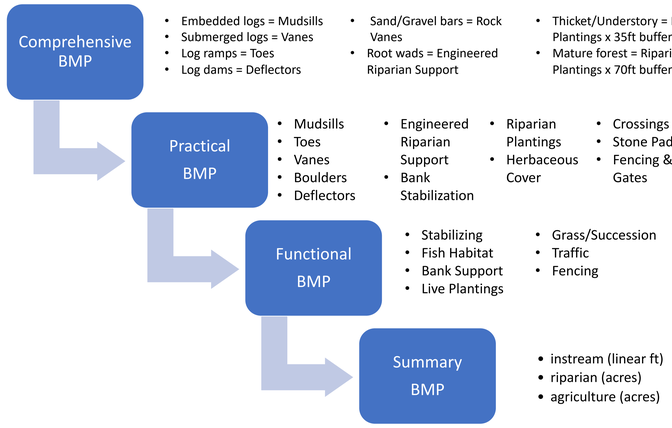

Figure 6: Four tier categorization breakdown of implemented BMPs. Notes beside each tier indicate what is included at that level. Tier 1 shows how forest reference stream information is correlated to BMP vocabulary

Results and Discussion:

Analysis showed that changes in fish population for most streams had the greatest improvement two years following restoration (Figure 7). The change in fish population response after two years was compared to the quantity of BMPs implemented at each site for all BMP categories. Fish populations were broken into subcategories: Minnows (Cyprinidae) and Sunfish (Centrarchidae) for additional analysis. The results are summarized in Table 1. No BMPs were statistically significant at the Summary category and the most BMPs indicated statistical significance at the Practical level. Relationships for positive changes in minnow population were especially strong at sites where deflectors, vanes, and toes were the prominent BMPs implemented (Figure 8). More specifically, Cutlip Minnows and Banded Killifish had a particularly strong positive response to the installation of vanes (Figure 9). These instream structures are particularly useful in redirecting the main flow of a stream away from the stream bank, reducing bank erosion, helping to narrow and center the existing stream channel, establishing grade control, and establish deeper pool habitats. This is important because it suggests that the implemented structures are functioning as intended and have indicated a positive response in fish population two years following restoration.

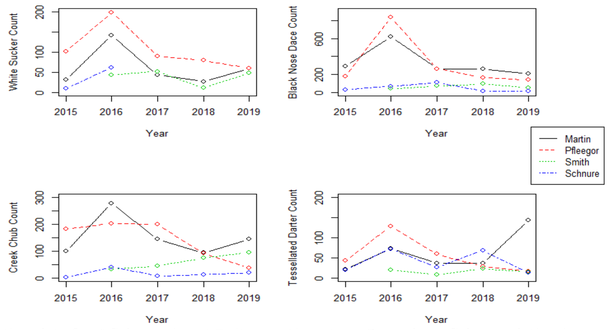

Figure 7: Fish population data for 4 fish species at 5 sites on Limestone Run where fish population increases 2 years after restoration took place

Table 1: Statistically significant connections between BMPs at the practical, functional, and summary levels and the changes in fish population two years after restoration took place for all fish species, minnows, and sunfish categories. P-values are shown in parenthesis.

	Practical	Functional	Summary
All Fish	Vanes (0.10) Toes (0.10)	None	None
Minnows	Crossings (0.10) Deflectors (0.10) Fencing/Gates (0.05) Vanes (0.05) Toes (0.05) Engineered Riparian Support (0.001)	None	None
Sunfish	Mudsills (0.10) Deflectors (0.10)	Succession (0.05) Fencing (0.05)	None
Lithophilic	Boulders (0.10) Fencing/Gates (0.10) Vanes (0.05) Toes (0.05)	None	None

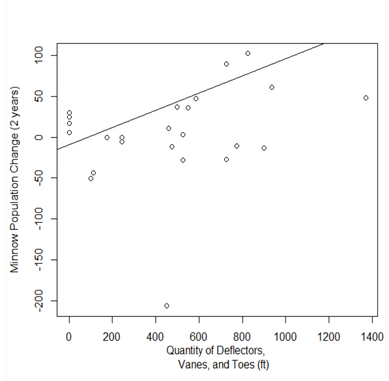

Figure 8: Relationship of minnow population 2 years post restoration and the quantity of deflectors, vanes and toes. R^2 value = 0.123, p-value = 0.44

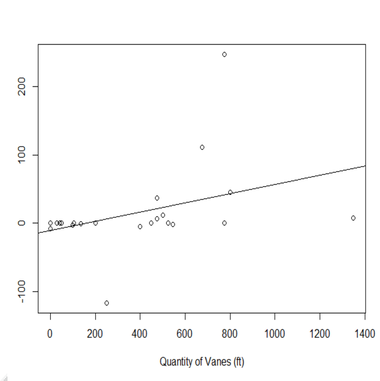

Figure 9: Cutlip Minnow and Banded Killifish population change and quantity of vanes implemented. R^2 value = 0.1467, p-value = 0.07

Conclusions:

Eight BMPs indicated statistical significance with respect to the change in fish populations two years after restoration took place. This significance was most apparent at the practical level. In most cases the statistical significance was lost when analyzing response at a broader scale (functional and summary levels). The results indicate that of the BMPs evaluated, instream BMPs, particularly vanes, were statistically significant most often. It is encouraging to find a positive response from fish populations, because it suggests that, in many cases, the implemented BMPs are functioning as intended.

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